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Effect of Improving Quality by Changing the Distribution Method of Shrimp Culture

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Abstract

Purpose: This study focuses on exploring ways to improve the distribution method of shrimp farming so that it is eco-friendly and increases the distribution of shrimp. **Research design, data and methodology:** The experimental device installed in a biofloc shrimp culture in one area tested 10 times. Complex odor, concentration of H_2S, water quality improvement effected by decomposition of organic substances, and degree of microbial activation measured. The data of the experimental results verified using the T-test technique, and the p value was determined based on the significance probability of 0.05. **Results:** This experimental device was effective in reducing odor and hydrogen sulfide in shrimp farms. With the improvement of water quality, dissolved oxygen increased due to the microbubble and cavitation action of air ejector and ultrasonic waves. In addition, the cultured microorganisms in the cultured water treated by the experimental device were remarkably proliferated compared to the raw water. **Conclusions:** The biofloc distribution method has a significant effect on improving water quality and reducing odor substances and will become a new eco-friendly and efficient distribution method for shrimp farming in the future.

Keywords: Distribution Industry, Shrimp Culture, Biofloc, Mass Farming, Microbial Culture

JEL Classification Code: I10, I11, I18, I19

1. Introduction

Well-being trend pursuing for agricultural safety and health has spread around the world, which leads to gradual increase in production and demand for organic food (Lee, Park, & Lim., 2011). The food is any substance consumed to provide nutritional support for the body (Park, & Jeong, 2012). Recently, the consumption of crustaceans among seafood has increased worldwide, and among them, the consumption of shrimp has increased remarkably. Shrimp is a diet that loved for seasoning, tempura, and grilling, and an increase in shrimp farms to meet the consumption of shrimp is inevitable. In response to the domestic demand for shrimp, when farms increase, countermeasures against water pollution and odors caused by farm wastewater are also necessary. Long-term contact with wastewater discharged from shrimp farms can cause diseases such as cholera. In addition, chemicals used to prevent shrimp disease (FAO, 2018) mixed with feed containing toxic gases and ammonia nitrogen, which causes odor, and shrimp feces. It can have serious adverse effects on the ecosystem.

In fact, in the Philippines of Southeast Asia, where shrimp farms are densely distributed, there is a case where ground water contaminated by the farm discharge water,

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making it impossible to use it as drinking water. Recently, the biofloc shrimp farming method as an eco-friendly shrimp farming method has been in the spotlight of academia and shrimp farmers. However, currently, the shrimp farming industry in Korea is 90% of the festival-style farms raised in natural fields (Baek, & Jeong, 2019). In the festival-style farming method, the mortality rate of shrimp due to chemicals, shrimp feces, and feed debris is close to 50%, causing environmental pollution and odor problems in nearby water systems. Therefore, in order to activate the biofloc shrimp distribution method, this study installed and tested an experimental equipment to compensate for the lack of microbial growth demand, which is a disadvantage of the biofloc shrimp farming method, at a biofloc shrimp farm located in Seocheon-gun, Chungcheongnam-do. An ultrasonic generator and an air ejector installed as a device to facilitate the metabolism of microorganisms to organic substances to help the growth of microorganisms. The ultrasonic generator and the air ejector facilitate the metabolism of microorganisms to organic substances by decomposing various organic substances and suspended substances in water into organic carbon form through cavitation and water hammer action, respectively. Therefore, this study attempts to study a method to reduce odor and improve water quality environmentally and economically by changing the distribution method of shrimp to consumers.

2. Theoretical Background

2.1. Shrimp Farming

Aquaculture is an aquatic environment mainly controlled by human activity (Zhou, Zeng, Hou, Liu, Weng, & Huang, 2020). The uncontrolled growth of shrimp farming has led to negative environmental impacts in many countries, which has increased concerns regarding the expansion of this activity (Poersch, Bauer, Kersanach, & Wasielesky, 2020). Globally, shrimp aquaculture has undergone a rapid development in the last decades, as it can help to satisfy the increasing food demand of a growing population (Dorber, Verones, Nakaoka, & Sudo, 2020).

Shrimp farming refers to cultivating freshwater or sea shrimp. In Korea, from the 1990s, farming began to flourish around the west coast, where large amounts of prawns produced. However, due to the mass mortality of the white spot virus, which is a viral disease, giant shrimp replaced by white-legged shrimp farming, which has a low incidence of disease. Shrimp culture industry has threatened by a tension of diseases that considered as a primary concern and a limiting factor (Flegel, 2006).

This trend is the same in the world. According to the FAO World Aquaculture Trends published by the Food Agriculture Organization (FAO), shrimp farming is the largest among crustaceans in recent years, and the production of white leg shrimp is the dominant. Shrimp farming and distribution methods generally referred to as shrimp farms in Korea, meaning a festival farm run in the open field. However, with the recent emphasis on eco-friendly industry, biofloc shrimp farming in plants is increasingly highlighting as a new shrimp farming distribution method.

2.2. Shrimp Farming Distribution

2.2.1. Shrimp Culture Ponds

The consumption of seafood is important to gain animal protein from the diet, and the global demand for seafood has increased in recent years because of its health advantages over meat proteins from terrestrial livestock (Stentiford, Neil, Peeler, Shields, Small, Flegeld, Vlak, Jones, Morado, Moss, Lotz, Bartholomayi, Behringer, Hautonm, & Lightnerm, 2012). In general, it refers to a culture that is cultivated in the open field, that is, outdoors, on the coast. It is a method of farming and circulating in an open-air nursery with a depth of 1.2 to 2 m on an average 3.3 ha coastal site. In fact, the distribution system is really in transition (NGO, 2021). Shrimp Culture Ponds are much lower in initial cost than plant farms, or water tank farms, because they do not require additional facilities other than facilities to supplement the site and cultured water.

Due to the characteristic of flow-through type, the standard of pollution level of discharged water is set low, so no special purification facilities are required. However, there are many restrictions due to natural conditions such as season, sunshine, air volume, and weather. In addition, since festival farms exposed to the outdoors, they are vulnerable to diseases such as infectious diseases, and chemicals are inevitable.

2.2.2. Biofloc Culture

During the last decade, biofloc technology (BFT) emerged as a potential solution for improving the sustainability of aquaculture (Bossier, & Ekasari, 2017). Biofloc can use as food or as a nutrient source for farmed shrimp, either through direct intake from culture water or as an ingredient (Castro, Pinto, & Nunes, 2021). The application of biofloc technology has been tested in an extensive range of culture species, including Pacific white shrimp, Litopenaeus vannamei (Tinh, Hai, & Verreth, 2021). Biofloc aquaculture is a distribution name for a farm that named biofloc aquaculture by the World Aquacultural Society (WAS) in Las Vegas, Nevada, USA in February 2006.

In biofloc farming, various suspended substances such as feces and feed debris of aquaculture organisms decomposed by microorganisms that artificially or naturally generated in the water of the farm, improving the water quality environment, and furthermore, the microorganisms themselves become nutrients for consumption of the aquaculture organisms. As an eco-friendly method, it prevents contamination of the surrounding ecosystem due to discharged water by eliminating the return water from the farm. A purification facility is required because it cleans and discharges sediment at the bottom of the tank. Therefore, the initial cost of biofloc farms is higher than that of festival farms.

2.3. Water Quality Environment for Distribution

The optimum aquatic environment for shrimp farms should maintain at least 3.5 to 6.0 ppm of dissolved oxygen. In addition, the concentration of NH_3 also changes depending on the carbon dioxide concentration and pH. In the afternoon when the concentration of carbon dioxide is low and the pH is high, the concentration of NH_3-N reaches its peak. NH_3-N is toxic to shrimp at concentrations of 0.1 ppm or higher, so the farms try to keep the concentration below 0.1 ppm. In addition, H_2S influenced by pH and water temperature, and it causes severe toxicity to shrimp even at 0.03 ppm, which smells of rotten eggs, and causes death at 0.1 ppm, so shrimp farms try to keep the concentration of H_2S as low as possible. In order to meet these demanding conditions for distribution of aquaculture, frequent exchanges are essential in festival-style farms, and the discharge of toxic substances deposited during recovery adversely affects the water quality environment and seawater in the surrounding area. Likewise, in biofloc aquaculture, toxic substances are contained in water, but they mitigated by microbial degradation.

2.3.1. Optimal Frequency for Microbial Activation

The optimal frequency radiation in water serves to decompose suspended and pollutants in the water. Microorganisms help the metabolism of microorganisms through decomposition substances due to frequency and consequently contribute to the activation of microorganisms. (Lee, & Kim, 2004). However, when the frequency of the ultrasonic wave is less than 60 kHz, the cavitation phenomenon is insufficient, and when the frequency of the ultrasonic wave is more than 120 kHz, even aquatic microorganisms are killed due to the influence of cavitation. It found that the power of 200 W and the frequency of 60 kHz to 80 kHz to affect microbial activation using ultrasonic waves are optimal.

2.3.2. Definition of Air Ejector and its Impact

Aerators are essential for maintaining the dissolved oxygen level in shrimp culture operations (Hwang, Seo, & Lee, 2019; Jayanthi, Balasubramaniam, Suryaprakash, Ravisankar, & Vijayan, 2021; Kim, Lee, Lee, & Kim, 2009). An ejector is a type of pump that moves a low-pressure fluid by using the velocity of a fluid injected at high pressure (Im, Jung, & Kim, 2014). In other words, when the fluid flows through a narrow passage, the speed increases and the pressure decreases, but when flowing through a wide passage, the speed decreases and the pressure increases. Fine bubbles generated in the air ejector using this principle. The generated microbubbles rise to the surface and burst, helping to raise the amount of dissolved oxygen, helping shrimp farming.

2.3.3. Overview of Microbial Carriers

A microbial carrier is a habitat for useful microorganisms, and useful microorganisms in the carrier repeat death and proliferation. Materials used as carriers include soil, compost, ceramics, sawdust, bark, wood chips, activated carbon, cork, polyvinyl, and polyurethane. As an economic problem due to frequent replacement cycles caused by brittleness due to its large hardness or the inability to withstand the pressure in the wastewater treatment equipment, polyvinyl alcohol (PVA) and polyurethane (PU) mainly used as carriers for the wastewater treatment equipment. In this experiment, a carrier made of PVA material, which is easy to obtain on the market and can promote durability and an economical efficiency, used.

3. Research Method

3.1. Research Flow Chart

The research process showed in Figure 1. The research device installed in a biofloc shrimp farm located in Seocheon-gun, Chungcheongnam-do, and samples collected before and after treatment by the experimental device. The concentration of complex odor and H_2S measured to determine the degree of reduction of odor-causing substances after installation of the research device. DO, pH, Turbidity, NO_2-N, and NH_3-N were measured to determine the effect of improving water quality by decomposition of organic substances, and the number of common bacteria, E. coli, and Bacillus bacteria were measured to determine the degree of microbial activation.

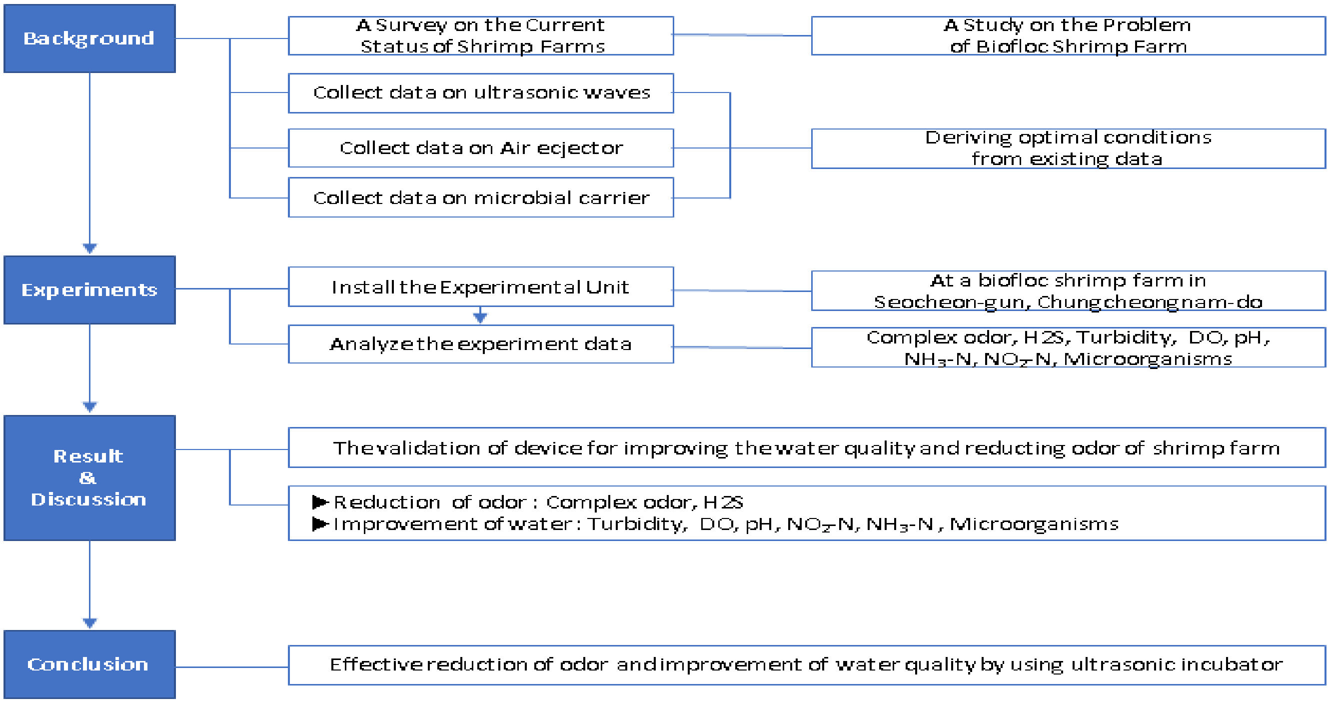

Figure 1: Research Flow Chart

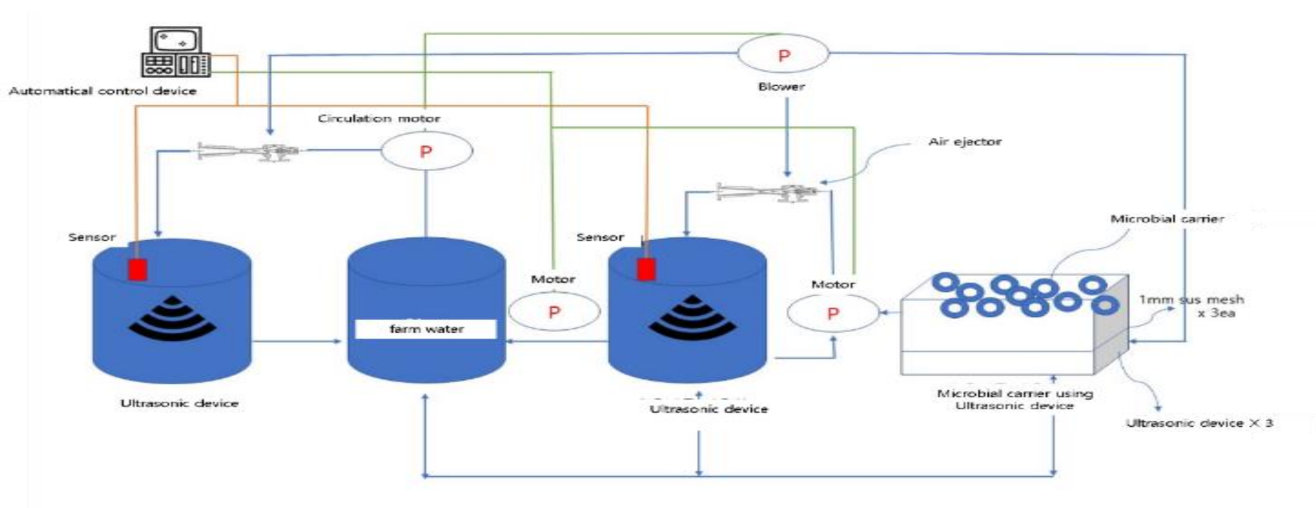

Figure 2: Schematic Diagram of Ultrasonic Culture Device

3.2. Experimental Materials and Number of Experiments

For the research experiment, an experimental device installed directly at a biofloc shrimp farm located in Seocheon-gun. Samples used in the experiment collected in the field for collection of complex odors and water quality analysis, and collected samples were stored refrigerated below 4°C. The experiment run over 10 rounds. Complex odor analysis and microbial population analysis carried out once per round, and water component analysis of H_2S, Turbidity, DO, pH, NH_3-N, and NO_2-N performed four times per round.

3.3. Experimental Device

The experimental setup shown in Figure 2. It consists of a culture tank (raw water), an air ejector, an ultrasonic device, and a microbial carrier. The culture tank was made of a PVC material, 6,000 mm long × 2,400 mm long ×

1,200 mm high, a rectangular parallelepiped, and the air ejector was made with an inlet diameter of 25 mm, an outlet diameter of 30 mm, and an injection part diameter of 10 mm. The ultrasonic generator manufactured using a 1,500 W oscillator for AC and a chemical reaction device through a vibrator.

3.4. Analysis Equipment

3.4.1. Analysis Equipment

The analytical equipment used in the experiment to measure pH, H_2S, Turbidity, NO_2-N and NH_3-N is a pH meter, gas chromatography (GC), Turbidity meter, UV/Vis Spectrometer, and UV/V is Spectrometer. SS, pH, NO_2-N, NH_3-N were analyzed in accordance with the water pollution process test standards, and complex odor and H_2S were analyzed according to the odor pollution test standards was conducted.

3.4.2. Method for Measuring and Analyzing Odor

The odor analysis agent checks the presence or absence of the odor recognition test by having all the preliminary judges smell the test solution of 1 degree of the odor recognition test. If the preliminary judge does not recognize the smell, it excluded from the subject of the judge selection test. For the panel that has passed the test, the test solution for recognizing odor strength is unsealed in a well-ventilated place to smell the odor in the order of 1 to 5 degrees to recognize the degree of odor strength. On the other hand, as a method for measuring the concentration of hydrogen sulfide, the suction box method used as the sampling method and the low-temperature concentration-capillary separation tube gas chromatography analysis method and the low-temperature concentration-filling type separation tube GC analysis method are used.

3.4.3. Microbial Medium Culture Method

A sample taken and the sample itself cultured in a medium for initial microbial identification. Then, 1 ml of the initial sample put into a 9 ml test tube, diluted 10 times, and the sample cultured again in medium. The same method can use to produce a sample that diluted 10 times continuously, and this method can dilute up to 10 times to obtain an approximate number of microorganisms.

4. Research Results and Discussions

4.1. Effect of Reducing Odor-causing Substances

Table 1 shows the results of 10 experiments. In a result of verification using the T-test technique, the T value was -24.80, and the p value was 1.35 × 10-9, which is less than the significance probability of 0.05, confirming that this experimental device is effective in reducing the odor of the shrimp farm. As can be seen in 3, the complex odor decreased from a maximum of 1,159 times to a minimum of 300 times.

Table 1: The Change of Complex Odor (Dilution Factor)

	0hr	48hr
1st experiment	965	300
2nd experiment	965	300
3rd experiment	1,159	373
4th experiment	965	300
5th experiment	1,159	373
6th experiment	1,159	373
7th experiment	965	300
8th experiment	1,159	300
9th experiment	965	373
10th experiment	1,159	300
Maximum to Minimum	1,159	300

Note: *n = 10, **t = -24.80, ***p = 1.35 × 10-9

In the case of hydrogen sulfide, the result values are as shown in Table 2, and the results analyzed four times for each time. The significance level of the p-value for each round was less than 0.05, indicating that the experimental apparatus had an effect on the reduction of hydrogen sulfide. Hydrogen sulfide reduced from 1.07 ppm to 0.25 ppm on average.

Table 2: The Change of H_2S (ppm)

	Mean ± S.D.(*n = 4)		t	p
	0hr	48hr		
1st experiment	0.79	0.13	-9.25	2.66×10^{-3}
2nd experiment	0.78	0.13	-7.77	4.42 × 10-3
3rd experiment	0.80	0.16	-7.39	5.10 × 10-3
4th experiment	0.72	0.13	-8.81	3.07 ×10-3
5th experiment	1.11	0.24	-15.00	6.39 × 10-4
6th experiment	1.16	0.24	-12.21	1.18 × 10-3
7th experiment	1.16	0.27	-19.37	3.00 × 10-4
8th experiment	1.39	0.38	-49.73	1.78 × 10-5
9th experiment	1.39	0.42	-18.29	3.56 × 10-4
10th experiment	1.41	0.35	-42.37	2.89 × 10-5
Average	1.07	0.25	-	-

4.2. Water Quality Improvement Effect

SS, or Turbidity, measured to determine the degree of treatment of suspended solids in the process of processing the cultured water of the shrimp farm by the experimental device. The degree of changes in DO, pH, NO_2-N, and NH_3-N due to the decomposition of suspended substances and organic substances due to microbial activation in the raw water of shrimp farming measured. Fig. 3 and 4 show the average of the results of the 1st to 10th experiments of each item in a graph. The p value of the experiment per round of each item did not exceed the significance level of 0.05. Therefore, it confirmed that this experimental apparatus had an effect on reducing Turbidity, DO, pH, NO_2-N, and NH_3-N. As for the pH, it found that the pH concentration increased due to the treatment of organic substances, that is, ammonia, of microorganisms, and it confirmed that suspended substances, NH_3-N and NO_2-N also decreased due to decomposition. In addition, dissolved oxygen appears to have increased due to the microbubble and cavitation action of the air ejector and ultrasonic waves.

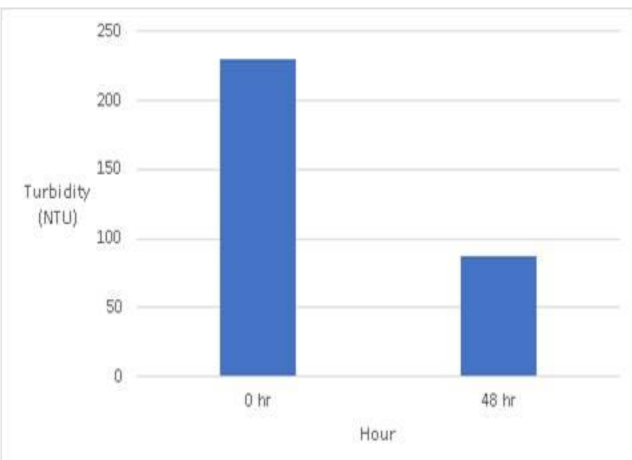

Figure 3: The Graph of Turbidity Changes

4.3. Microbial Culture Results

The culture of the medium of general bacteria and E. coli made with Petri film medium of company, and the experiment performed with yellow medium for general bacteria and brown medium for E. coli. In the case of Bacillus bacteria, Agar medium containing nutrients used, and the color of the medium was red. As a result, of conducting T-test with the result of the 10th experiment, the proliferation result of general bacteria, E. coli, and Bacillus bacteria showed that the p value was less than the significance level of 0.05. It confirmed that this experimental device has an effect on the growth of microorganisms.

Table 4: The Changes of *Escherichia coli* (CFU/mL)

	0hr	48hr
1st experiment	10^3	10^6
2nd experiment	10^2	10^6
3rd experiment	10^3	10^5
4th experiment	10^3	10^5
5th experiment	10^2	10^6
6th experiment	10^3	10^5
7th experiment	10^2	10^6
8th experiment	10^3	10^6
9th experiment	10^2	10^6
10th experiment	10^2	10^5
Minimum to Maximum	10^2	10^6

Note: *n=10, **t = 4.34, ***p = 1.85 × 10-3

Table 5: The Changes of Bacillus sp. (CFU/mL)

	0hr	48hr
1st experiment	10^3	10^6
2nd experiment	10^3	10^7
3rd experiment	10^3	10^7
4th experiment	10^2	10^6
5th experiment	10^2	10^6
6th experiment	10^2	10^6
7th experiment	10^3	10^7
8th experiment	10^3	10^6
9th experiment	10^2	10^6
10th experiment	10^2	10^6
Minimum to Maximum	10^2	10^7

Note: *n=10, **t = 2.69, ***p = 0.02

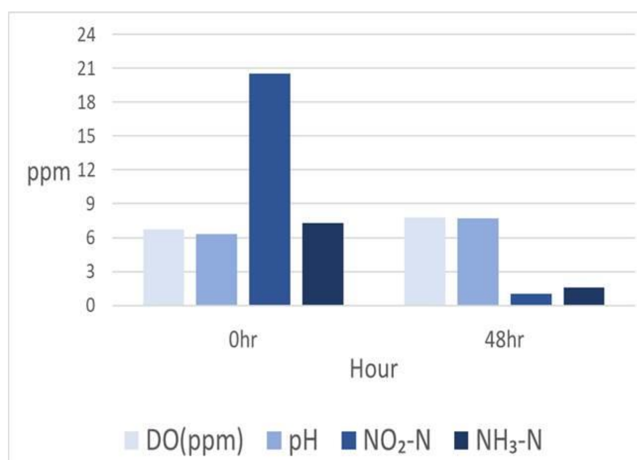

Figure 4: The Graph of DO, pH, NO2-N and NH3-N Changes

4.4. Effect of Experimental Device on Shrimp Growth and Survival

In terms of the survival rate of shrimp, the survival rate of shrimp for shipment by the conventional shrimp biofloc farming method is about 80% on average. However, the survival rate of the shrimp, which confirmed at the time of shipment after installing this experimental device, was more than 90%. Looking at the growth side of shrimp, the average size of white leg shrimp on the market is 15 to 16 cm, and the average weight is 25 to 30 g. The average size of the shrimps confirmed at shipping in the farm where this experimental device installed was 16.5 cm and the weight was 31 g, and they grew to the size and weight of oversized or king shrimps sold on the market.

5. Conclusions

Brand experience results from stimulation and leads to pleasant results, and consumers want to repeat this experience (Budi, Hidaya, & Mani, 2021). In this study, by installing ultrasonic waves, air ejectors, and microbial carrier tanks in the shrimp farm to treat cultured water with an experimental device, the following conclusions can draw by enhancing microbial activation. In this study, the conclusions are divided into theoretical and practical implications.

In conclusion, the theoretical aspect of the study is set, and practical conclusions for the theory are described based on the experimental results.

5.1. Sonochemistry reaction by ultrasonic generator

When ultrasonic waves are irradiated in water, bubbles are generated due to the effect of generating sound pressure by the ultrasonic waves, and these bubbles are repeatedly contracted and exploded by the continuously irradiated ultrasonic waves. This is called a cavitation phenomenon, and in this study, it is expected that the use of the cavitation phenomenon can create an environment in which microorganisms can more smoothly metabolize suspended substances due to the resulting decomposition of suspended substances.

In practical implications, in this and previous studies, when the water quality was improved using an ultrasonic culture device, as a result of culturing the culture medium with a microbial activity of 10^8, it was confirmed that microorganisms such as general bacteria, Bacillus bacteria, and E. coli were significantly increased. Therefore, it could be concluded that the negative chemical reaction by the ultrasonic generator has a positive effect on the activation of microorganisms.

5.2. Water hammer action by air ejector

In an air ejector using Bernoulli's law that the total energy is constant in a continuously flowing fluid system, pressure energy is converted into velocity energy at the front end of the ejector where the nozzle diameter decreases as high pressure fluid passes through the air ejector. The pressure drops at the nozzle neck, and a low pressure fluid is supplied due to this reduced pressure. Micro bubbles are generated by this layer push phenomenon. As a result of this phenomenon, microbubbles are generated at the tip of the nozzle, which is expected to increase the amount of dissolved oxygen as these microbubbles rise to the surface and burst.

In practical implications, as a result of treating the shrimp farm nursing water using an ultrasonic culture device, there was an improvement effect of about 15% from 6.79 ppm to 7.98 ppm. Unlike wastewater research, this study was conducted with aquaculture water that can live in real shrimp, not wastewater. Therefore, the DO value before treatment was not so low that the improvement effect was not remarkable. However, the original purpose of increasing the microbial proliferation activation using ultrasonic waves and air ejectors, the purpose of this study, was confirmed by the noticeable increase in microbial activity.

5.3. Increased microbial activation rate due to carrier installation

Different results were expected from previous studies in which experiments were conducted using only ultrasonic waves and air ejectors. It was expected to have a positive effect on the growth of microorganisms by securing the metabolic time of the underwater microorganisms by installing a culture tank containing a carrier of 3 cm in width and 2 cm in height.

In practical implications, when the study was first planned, the experiment was conducted with only ultrasonic waves and air ejectors, as in previous studies. However, unlike previous studies in which the experiment was conducted in a closed environment by collecting wastewater, the rate of microbial activation is serious due to the semi-open experimental environment in which the water collected from the device must be supplied back to the farm for a certain period of time in the actual farm. It was low enough. However, as shown in the text result, by installing a carrier, it is possible to confirm the degree of remarkable activation of unlife.

References

Baek, J. Y., & Jeong, M. J. (2019). An Economic Feasibility Comparison Analysis on White Shrimp (Litopenaeus Vannamei): Aquaculture with Biofloc Technology. *Journal of Fisheries and Marine Science Education, 31*(5), 1408-1416.

Bossier, P., & Ekasari, J. (2017). Biofloc technology application in aquaculture to support sustainable development goals. *Microb. Biotechnol, 10*(2017), 1012-1016.

Budi, S. C., Hidaya, Z., & Mani, L. (2021). The Effects of Experience and Brand Relationship to Brand Satisfaction, Trust and Loyalty Shopping Distribution of Consumer Philips Lighting Product in Indonesia. *Journal of Distribution Science, 19*(1), 115-124.

Castro, L. F., Pinto, C. C., & Nunes. A. J. P. (2021). Nutrient value and contribution of microbial floc to the growth performance of juvenile shrimp, Litopenaeus vannamei, fed fatty acid and amino acidrestrained diets under a zero-water exchange intensive system. *Aquaculture, 531*(2021), 735-789

Dorber, M., Verones, F., Nakaoka, M., & Sudo. K. (2020). Can we locate shrimp aquaculture areas from space? – A case study for Thailand. *Remote Sensing Applications: Society and Environment, 20*(2020), 1004-1016.

Flegel, T. W. (2006). The special danger of viral pathogens in shrimp translocated for aquaculture. *Sci. Asia, 32*(2006), 215–221.

Food Agriculture Organization. (2018). The State of World Fisheries and Aquaculture. *The State of World Fisheries and* Aquaculture, *5*(1), 11-16.

Hwang, W., Seo, H. J., & Lee, M. C. (2019). Experimental Study on a Temperature Measurement Method Using Ultrasonic Wave for the Safe Operation of Gas Turbines. *The Korean Society of Mechanical Engineers, 43*(2), 93-98.

Im, S. D., Jung, Y. D., & Kim, J. R. (2014). Development of Diagnosis of Trouble Model for Effective Operation of Air-compressor. *Korea Safety Management & Science, 16*(3), 239-248.

Jayanthi, M., Balasubramaniam, A. A. K., Suryaprakash, S., Veerapandian, N., Ravisankar, T., & Vijayan. K. K. (2021). Assessment of standard aeration efficiency of different aerators and its relation to the overall economics in shrimp culture. *Aquacultural Engineering, 92*(Feb), 1021-1042.

Kim, T. Y., Lee, J. Y., Lee, D. K., & Kim, Y. J. (2009). Development of rotor profile design technology for improving the screw compressor performance. *The Korean Society for Railway, 46*, 585-592.

Lee, H. J., & Kim, D. H. (2004). Improvement of Water Quality in Shrimp Aquaculture Farms of Southwestern Coastal Area of Korea. *The Korean Society for Marine Environment & Energy, 7*(4), 159-163.

Lee, Y. C., Park, C. J., & Lim, S. J. (2011). An Exploratory Study on Specialty Stores for Organic Foods. *Journal of Distribution Science, 9*(3), 47-54.

NGO. (2021). Food Distribution System in Vietnam: Nash Equilibrium and Channel, Choice of Small Scale Farmers. *Journal of Distribution Science, 19*(1), 61-73.

Park, C. J., & Jeong, T. S. (2012). Study on the Measurement of Management Performance based on BSC: Examining Japanese Food Manufacturers. *Journal of Distribution Science, 10*(11), 11-20.

Poersch, L. H., Bauer, W., Kersanach, M. W., & Wasielesky, W. (2020). Assessment of trace metals, total organic carbon and total nitrogen of a shrimp farm system in Southern Brazil. *Regional Studies in Marine Science, 39*(September), 1014-1052.

Stentiford, G. D., Neil, D. D., Peeler, E. J., Shields, J. D., Small, H. J., Flegeld, T. W., Vlak, J. M., Jones, B., Morado, F., Moss, S., Lotz, J., Bartholomayj, L., Behringer, D. C., Hauton, C., & Lightnerm, D. V. (2012). Disease will limit future food supply from the global crustacean fishery and aquaculture sectors. *Journal of Invertebrate Pathology, 110*(2), 141-157.

Tinh, H. T., Hai, T. N., Verreth, J. A. J., &. Verdegem, M. C. J. (2021). Effects of carbohydrate addition frequencies on biofloc culture of Pacific white shrimp (Litopenaeus vannamei). *Aquaculture, 534*(15), 736-753

Zhou, R., Zeng, S., Hou, D., Liu, L., Weng, S., & Huang, Z. (2020). Temporal variation of antibiotic resistance genes carried by culturable bacteria in the shrimp hepatopancreas and shrimp culture pond water. *Ecotoxicology and Environmental Safety, 199*(August), 1107-1158.